MINI-SMIFTS: A HIGH SPATIAL RESOLUTION THERMAL INFRARED SPECTROMETER FOR MARS LANDERS. P. G. Lucey[1*] B. B. Wilcox[1] J. J. Gillis[2] and V. E. Hamilton[1], [1]Hawaii Institute of Geophysics and Planetology, University of Hawaii, 2525 Correa Road, Honolulu, HI 96822. [2]Department of Earth and Planetary Sciences and the McDonnell Center for the Space Sciences, Washington University, St. Louis, MO 63130. [*]Correspondence author's email address: lucey@higp.hawaii.edu.

Introduction: We are developing an imaging infrared spectrometer for Mars landed missions that will provide significantly higher spatial resolution than mini-TES, and collect these data at much higher rates. Our instrument will follow on the heels of highly successful thermal infrared instruments, with another pair of thermal IR spectrometers expected to land on Mars in the next two years (MER/Athena Mini-TES). MiniTES offers high spectral resolution but has relatively low spatial resolution (8 mrad at its highest angular resolution mode, compared to 0.25 mrad for Pancam). The advantage of the instrument proposed here is that it will incorporate some of the best characteristics of the existing orbital and lander instruments, plus some new advances, and put them together in one instrument package. The data that would be collected from a flight instrument based on our PIDDP instrument would then be well-suited for bridging the spectral and/or spatial resolution gaps in the current and future instruments.

The instrument proposed here for development will cover the wavelength range from ~7 – 16 microns (the range of THEMIS) at moderate spectral resolution (~10 cm^{-1}), comparable to that of TES. We will significantly improve upon the spatial resolution of the Mini-TES instrument with an IFOV 1.0 mrad, versus 8 or 20 mrad for Mini-TES. Although a wider spectral range would provide additional spectral information (e.g., inclusion of the 15 – 50 µm range, as with TES), studies have shown that the <14 µm range is more than adequate for detection of major mineral identification and abundance quantification. The confidence of the Mars community in the information content of the narrower wavelength range was demonstrated by the selection of the THEMIS instrument for 2001 Mars Odyssey; however, the THEMIS instrument has only 10 channels (covering nine unique bandpasses) within this region. These relatively broad bandwidths will necessarily limit the level of detail that can be achieved in quantitative mineralogical investigations with THEMIS. Our instrument will maintain a higher band density (about 50 as opposed to 9) in this range, comparable to TES and Mini-TES, permitting more confident and detailed mineralogical analysis. Perhaps the most important improvement with our instrument is increased spatial resolution, which will permit a significantly more detailed analysis of targets by the analysis of multiple small spots on the target. The selectable 8 and 20 mrad IFOVs of the Mini-TES provide some "focusing" ability, but the area measured on any individual target still will be large. This kind of measurement is excellent for examining the bulk mineralogy of a target, but less useful for attempting to isolate a specific area of a target for detailed analysis, such as the weathered (or fresh) surface of a rock.

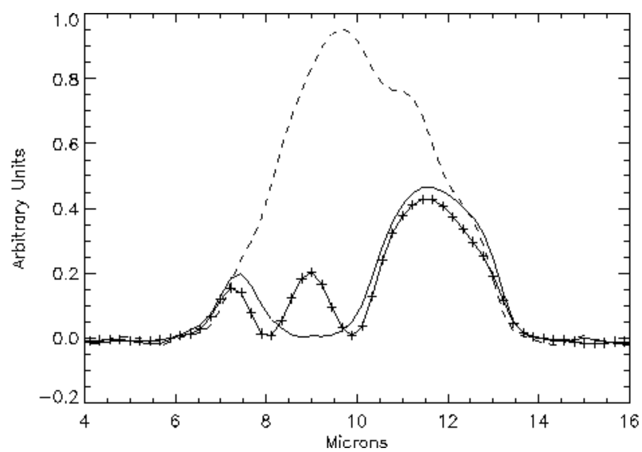
Instrument Concept: The proposed development is an IR interferometer that uses no moving parts and a microbolometer uncooled thermal IR detector array. Imaging Michelson interferometers have been used in astronomy and remote sensing for many years and have been proposed for planetary missions. However, a Michelson interferometer requires a moving mirror that adds complexity to a space instrument. Horton, 1996 [1] proposed to use a spatially modulated interferometer that distributes the interference pattern across the detector array and image. To obtain the full spectrum, the image is scanned across the scene so that every element is exposed to every optical path difference. The image cube is then reconstructed in post-processing. The concept was verified by Horton et al. 1997 [2] showing that hyperspectral imaging data could be obtained using this technique.

Claims to the contrary, for detectors operating in the region of photon noise dominance, there is little advantage to this interferometric method over competing dispersive techniques. Signal to noise ratios are similar as is complexity, and post processing is somewhat more intensive. However, in the infrared where cooled detectors are prohibitively resource-intensive for Mars surface applications, an interferometer is the only method to obtain true hyperspectral data with an uncooled detector. Uncooled infrared detectors are read-noise dominated, and the full multiplex advantage is preserved in interferometers versus filter or dispersive techniques.

Our instrument concept is based on a Sagnac interferometer that provides the wavefront division required for interferometry. The instrument requires a scan mechanism, but as such a mechanism is required to point any imaging sensor, this capability is inherent (though the precision of the scan may impose additional requirements on the scan mechanism).

We developed a proof of concept system that is far from optimum, but demonstrated that we could obtain usable interferograms and recognizable spectra (Figure 1). Scaling the results from these experiments to a flight system, we find that we can obtain data for 1 mrad targets at a rate 1000 times higher than miniTES at comparable resolution (~500). Our PIDDP project is aimed at confirming this assertion.

References: [1] Horton, R F., Proc. SPIE Vol. 2819, p. 300-315, Imaging Spectrometry II, Michael R. Descour; Jonathan M. Mooney; Eds., 1996; [2] Horton, R F., Conger, C. A., Pellegrino, L. S., Proc. SPIE Vol. 3118, p. 380-390, Imaging Spectrometry III, Michael R. Descour; Sylvia S. Shen; Eds.1997



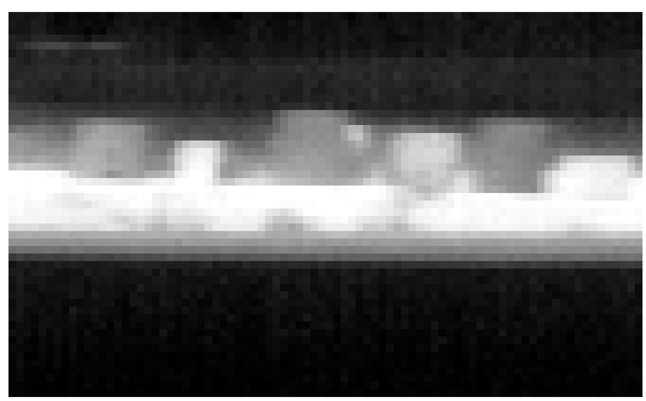


Figure 1. Top: Raw spectra obtained of calibration panels. Bottom: Preliminary imaging of panels.